Chapter 1

1.1 Overview of Computer Systems

1.1 The Parts of a Computer System

Let us first look at what a Computer and a Computer System is.

A computer can be classified as a device that takes in raw data as input and processes it and provides information as the output. The computer also has the ability to store data and information.

The computer system consists of hardware (Physical components), software and users (people who use the computer) that are necessary to make the computer function and to processes data in a meaningful way and store data.

The physical organisation of devices and the organisation according to functionality of a computer system can be developed by reference to the above definitions. Figure 1.1 and figure 1.2 can be used to illustrate this physical and functional organisation of a computer system.

A study of the figure 1.1 and figure 1.2 shows that a computer system has four clear categorisations for hardware and functionality of that hardware. They can be listed as:

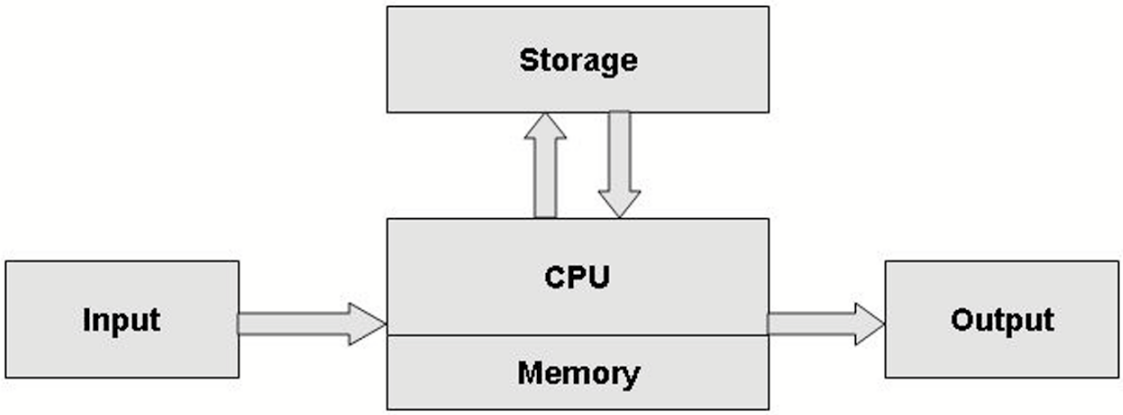


Figure 1.1: Hardware components of a computer

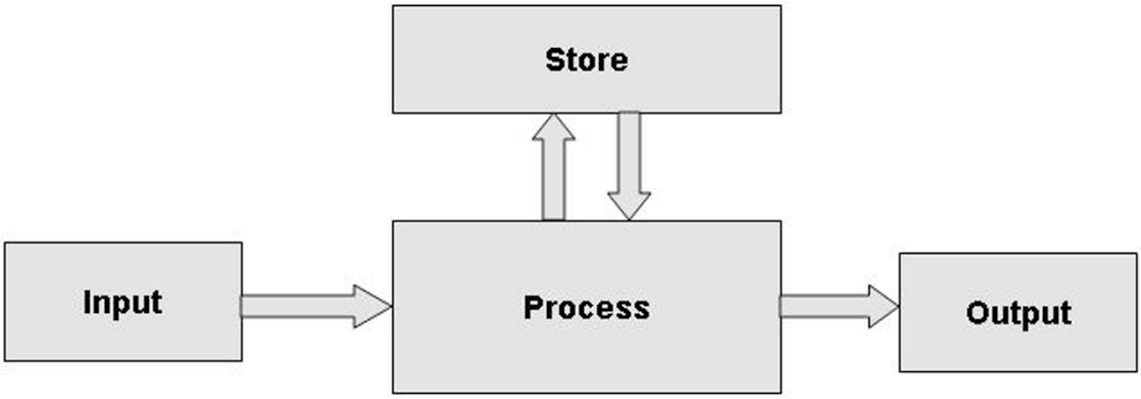


Figure 1.2: Logical design of the components of the computer

1. Processor, memory and integrating devices
2. Input devices
3. Output devices
4. Storage devices

All hardware components in a computer can be put into one of these four categories. Following are some of the hardware devices that are commonly found in modern day computer.

Processor, memory and integrating devices

- Central Processing Unit (CPU)
- Motherboard or Main board
- Main Memory
- Power supply
- VGA card
- Sound card
- LAN Card
- TV Card

Input Devices

- Keyboard
- Pointer device (e.g. Mouse, track-ball)
- Joystick and Game Pads
- Scanner
- Microphones, Still Digital Cameras and Video Cameras

Output Devices

- Monitor and LCD Panel
- Printers
- Speakers
- Plotters

Storage Devices

- Hard drives
- DVD and CD ROM
- Tape Drives
- Flash Disks and Memory Cards
- Floppy disks

Computer Hardware

This section gives a description of the features and the functionality of the parts of a computer.

The processor

The human brain can be considered as the organ that does all the analysis of the information we receive through our five senses: sight, smell, touch, hearing and taste (figure 1.3). It then produces appropriate responses to the information we received. The information received by the brain, the thoughts and ideas it generated is retained in the brain. Further more it is the organ that controls the functionality of our body's organs and parts. The brain is also capable of independent and creative thought and the generation of new ideas. The human brain learns some of its functionality and control through experience (learning) and some through instinct.

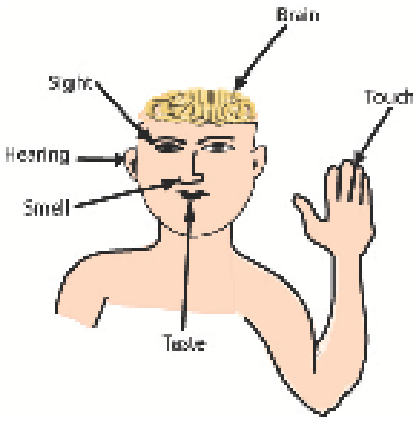


Figure 1.3: The Human Brain and its Sensors

The computer's equivalent to the brain is referred to as the processor. It is capable of receiving information from its input devices and then processing that information and to provide an output (figure 1.4). It also has the capability to store this information in a storage device. The processor is responsible for controlling the various devices of a computer.

Figure 1.4: The Processor and its inputs

The major difference of the processor from the human brain is that it is incapable of independent and creative thought and the generation of new ideas. The processor is also incapable of learning. It is a device that can only follow the instructions that have been given to it by the programmer.

There are many manufactures of processors in the world. Intel with their Pentium, Celeron and Xeon Processors, and Advanced Micro Devices Inc. (AMD) with their Duron and Athlon processors are biggest processor manufactures for the PC. There are other manufactures like Centaur Technologies with their Cyrix processor for the Personal Computer (PC). Sun Micro Systems with their SPARC chip is the company that develops processors for the Sun systems. Where as IBM with their PowerPC and Motorola with their Motorola 6800 are processors manufactures for the Apple computer. The most modern processors being manufactured are the Hyper-threading processors and the 64-bit processors.

Memory

The memory considered in this section is divided into two basic types. Random Access Memory (RAM) and Read Only Memory (ROM). The RAM can be explained as a device that temporarily store data. RAM can be read from and also written into. The key feature of the RAM is that when power of the computer is switched off the data in the RAM is lost (Volatile memory). As access to RAM is very much faster than to a permanent storage device, it is an inefficient method to read and write to permanent storage as it will simply slow the processing down a great deal. Therefore during processing it is important

to store programs and data in a temporary storage location. The Main memory has been developed for this purpose. The most common reference to the term 'Memory' in a computer is when referring to the Main Memory. Main Memory is also referred to as the RAM by many. Read Only Memory (ROM) as implied by the term is a type of memory which can only be read from. This type of memory does not loose its data when the power of the computer is turned off. The most common ROM in the computer is the BIOS (Basic Input Output System) ROM. The CMOS (Complementary Metal Oxide Semiconductor) chip is also belongs to volatile memory since it requires power from a battery to retain the data once the computer is turned off.

Input and Output Devices

Input and output devices are the devices of a computer that are used to interact with the user.

Input devices

Like the eyes, ears, nose, tong and skin provides a way to sense information about the environment and feed it to the brain, input devices helps the user to provide commands to the processor and also for the processor to receive data and information from its environment. The user can use devices like the keyboard, mouse or trackball and joystick to provide commands and data into the computer. Device like, the microphone, scanner and digital cameras help the processor to receive data from its environment. Any device that can feed data or information to a computer is referred to as an input device.

Output devices

Similar to body parts being used by the brain to output information and to interact with the environment, the computer uses output devices to output information to the user. All information which is outputted by the processor through the output devices can either be seen, heard or felt. Devices like the Monitor or LCD panel and projectors display information whereas a speaker would provide audible output. A feedback joystick would provide an output which can be felt by the user. Any device that can be used to output information from a computer is known as an output device. It is also important to note that certain devices have functionality that fall into both input and output categories. For example a touch-screen display and a feedback joystick function as both input devices and output devices.

Storage Devices

The computer ROM does not have enough capacity to store data, whereas the RAM is volatile and looses data once the power is turned off. Therefore there is a necessity for devices that could store data permanently. Previously data was stored in punch cards (a card with holes punched representing 1s and 0s) before the invention of magnetic storage devices and then optical storage devices. With the improvement of technology it was possible to manufacture devices that could store data in excess of 250 gigabytes (1 bit is a 1 or a 0, 8 bits is 1 byte, 1073741824 bytes is 1 gigabyte). The magnetic tape was one of

the earliest forms of data storage device but had a disadvantage since it had to be accessed in a sequential manner. The introduction of hard disk and floppy disk made it possible for data to be stored and accessed (randomly). The hard disk was not meant to be portable and was known as fixed disk located inside the computer. External hard disks were developed but not for the purpose of portability since they were fragile and prone to strong vibrations. Portable magnetic storage devices like floppy disk had a very limited storage capacity, this was changed with the invention of the ZIP disk which could store over 100 megabytes (1048576 bytes is 1 megabyte). The invention of the optical storage disks like the CD ROM and the DVD ROM made it possible to store data on disks which were not affected by magnetic fields, was easier to transport, and cost effective to produce. The typical CD ROM could store around 700 megabytes whereas the DVD ROM could store in excess of 4.2 gigabytes and now with improved Blu-ray (blue laser) format storage can go up to 27 gigabytes.

The size of all of these disks was somewhat cumbersome (with every device invented in the modern world becoming smaller and much more portable). With this requirement new disk and memory like the flash-drive (pen drive), SD card, Compact-Flash, Sony Memory stick and the XD picture-card have emerged. Some of these devices have a capacity that could exceed 12 gigabytes and are commonly used for storage in small digital devices.

Expansion cards and other components

The processor, Memory, Input/Output devices and storage devices need to be integrated together to function. These components have to be placed on a board called the Main-board or the Motherboard. Without this the computer cannot function. Some additional circuit boards may be required to integrate additional devices if they are already not embedded into the motherboard. These circuits are commonly referred to as cards. They are plugged into expansion slots available on the motherboard. Some of the most common cards are the Video Graphics Adapter card, Sound card, Ethernet card, TV card, Data-Fax Modem card, USB card and FireWire card. These cards provide expansion to the motherboard and the ability to connect other input, output and storage devices.

There are additional cables that are required to connect devices. Hard disk and floppy drive ribbon cables, CD/DVD drive analog audio cable, video cable, printer cable, USB cables and the FireWire cables are some of the most common cables found in a computer.

In addition to the devices mentioned above, there are technologies to connect computers to external devices like mobile phones, PDAs (Personal Digital Assistant) and Laptops. Such technologies create a direct connection between the computer and the external device. Some of the most common technologies are Blue-tooth (wireless), IrDA (infrared) and Wi-Fi (wireless).

Chassis and Power supply

All of the components of a computer system require power to function. Further more computer systems are encased in an enclosure. The units that provide the power and the enclosure are known as the power supply unit and the chassis respectively. There are

additional cables that are required to connect the power supply to the wall power outlet and the devices to the power supply. They are the power cables and power connectors.

Chassis

The chassis consist of space for the motherboard, power supply, input/output connectors, expansion cards, expansion bays, switches and wires to connect them to the motherboard and indicator Light Emitting Diodes (LEDs). The motherboard in an ATX tower casing (figure 1.5) is screwed on to the right side panel of the chassis and the input/output connectors of the main protrude from the rear. The expansion slots are on the bottom right side of the rare. The power supply is located on the top left side of the rear. While the power supply fan helps to cool the power supply, it also sucks out the hot air away from the CPU.

Figure 1.5: ATX tower casing

The chassis is usually made from steel, aluminum and/or plastic. Chassis come in various sizes defined using form factors. ATX is one of the most popular form factors, but according to the requirement different form factors may be used (e.g. tower, flatbed). Form factors are a standard in motherboards. The form factor implies the dimensions where the screw holes, CPU, RAM, input/output connectors, expansion slots are located and the type of power connectors. Therefore it is clear that the chassis should have a certain standard. The type of motherboard it supports can be used to refer to the chassis, but there are some exceptions. Hence, a form factor for chassis has been developed according to their specific shape.

For example a chassis with an ATX motherboard and an ATX power supply may still take a chassis form factor like tower, flatbed. The tower chassis can be further divided into mini-tower (figure 1.6), mid-sized tower (figure 1.7)and full-size tower (figure 1.8). The flatbed chassis can be further divided into desktop (figure 1.9) and slim desktop (figure 1.10). The tower is taller and much more spacious, where as the flatbeds are more compact and saves occupying space.

Figure 1.6: Mini tower casing

Figure 1.7: Mid-size tower casing

Figure 1.8: Full-size tower casing

Figure 1.9: Desktop flatbed casing

Figure 1.10: slim-desktop flatbed casing

Drive bays

Drive bays are a part of the chassis which is used to house drives such as the hard disk, CD/DVD Drives and floppy drives. The drive bays come in two standard sizes according to their width. They are:

- 3 inch bay - house the hard disk and the floppy drives usually.
- 5 inch bay - house the CD/DVD drives

The drives housed in these drive bays are held in place using screws. The drives are connected to the motherboard via data cables and the power is supplied through the power connectors of the power supply.

Power supply

The power required by the computer system is supplied by the power supply (figure 1.11). The power supply takes in 110 or 230 volts and converts it into voltages ranging from -12 to +12. The voltage selector lets the user select between 110 volts and 230 volts, which is based on the voltage of the main power source. In Sri Lanka it is 230 volts. If you select the wrong voltage it could cause permanent damage to your computer.

Figure 1.11: Power unit

The main power is connected to the power supply through a power cable (figure 1.12). The power required by the devices is supplied through the power connectors of the power supply. The power connectors come in different shapes and sizes. They also supply different voltages. To avoid the incorrect connection of the power connectors to the devices they usually have special shapes or keys.

Figure 1.12: Power cable

Some of the power connectors are listed below (figure 1.13).

- Mini plug - provides power to the floppy drive
- Molex power connector - provides power to hard drives, CD/DVD drives and SCSI (Small Computer System Interface) drives
- Motherboard power connector - These can defer according to the form factor of the motherboard, but their primary task is to provide power to the mother board
- 12V ATX power connector - this is required to provide additional power to the Pentium 4 processor. This is plugged into the motherboard
- SATA (Serial Advanced Technology Attachment) power connector - provides power to the SATA hard drive

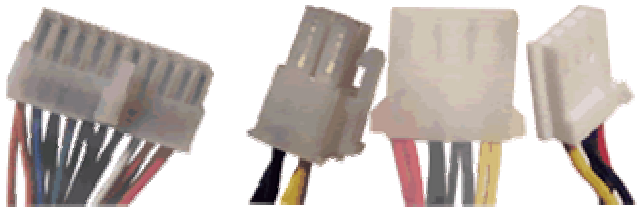


Figure 1.13: Power connectors

Buttons and indicators

The power button and reset button are located on the front panel of the chassis. The LEDs that indicate the power and the hard disk operation are located on the front panel of the chassis. Most chassis come with a speaker. All the above components are connected the motherboard via a set of wires. Advanced chassis come with chassis intruder detection switches, and panels which indicate the chassis temperature and fan speed.

1.2 Evolution of computers and Computers today

This chapter discusses the history and the development of the computers. First the chapter gives you an idea about the history of computers. Next it gives an explanation about modern day computers. In order to have a complete understanding about computer systems it is quite important to know about how the computer has evolved from its inception.

History

The history of any area is important in understanding it. Knowledge about the history will give you an overall idea (or the big picture) of how the computers today has evolved to this extent. The knowledge about history will help us in understanding the computers today and the significant milestones they have achieved from its inception.

1.2.1 Key developments

Many new ideas have contributed significantly to the development of computer systems. Some of the key developments of computer systems from the past are:

- Abacus - calculating device (3000 BC)
- Pascaline - mechanical adding machine (1642)
- Babbage - analytical engine (1830s)
- Ada - first programmer (1800s)
- Punched cards - data storage (1800s)
- Hollerith - tabulating machine (1890s)
- Mark I - general purpose computer (1944)

- ENIAC - electronic computer (1946)
- UNIVAC - US Census Department (1951)
- EDVAC - Stored Program Concept (1951)
- Generation of Computers
- Classification of Computers
- Microprocessor chip
- Floppy disk for data storage
- Pocket Calculator
- Apple II - first personnel computer
- IBM PC
- Portable computers
- Laser Printing and Desktop Publishing
- Multimedia desktop computers
- Home video computers
- Video conferencing

Details in brief

Abacus (3000 BC): Abacus (figure 2.1) is an ancient calculating device. This is still being used in China, Russia and the Far East.

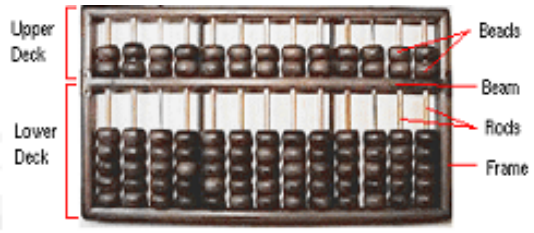


Figure 1.14: Abacus

Pascaline (1642): Pascaline (figure 2.2) is a desktop mechanical adding machine. This was developed by Blaise Pascal.

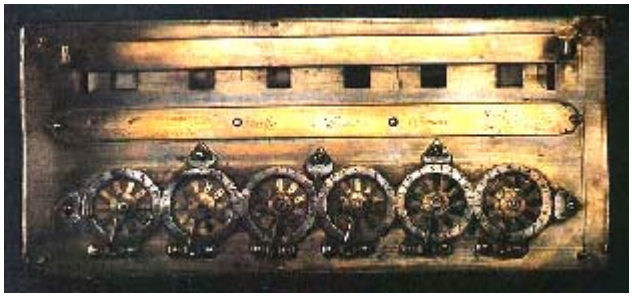


Figure 1.15: Pascaline

Analytical Engine (1830s): This was invented by Charles Babbage who is known as "the father of computers". Designed to store one thousand 50 digit numbers for calculations and decisions (figure 2.3).

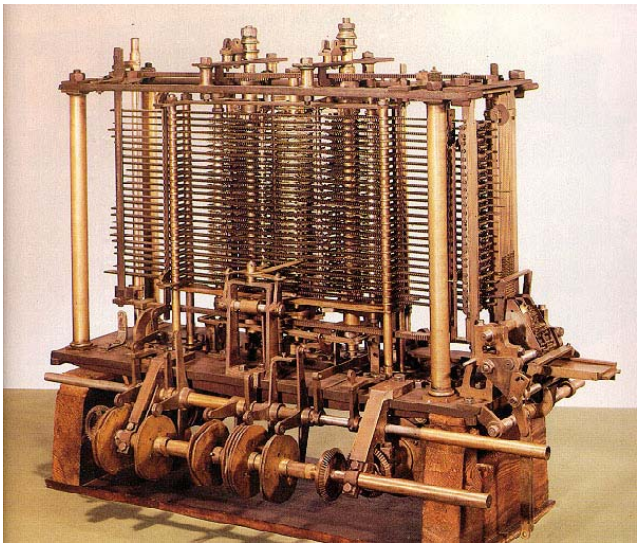


Figure 1.16: Analytical Engine

Ada (1800s): This is probably the world's first computer programmer. Collaborated with Charles Babbage.

Punched Cards (1800s): A card punched with holes (figure 2.4) in certain places so that a computer can read data coded from the combination of holes. This was first used by Joseph Jacquard to automate his weaving factory.

Tabulating machine (1890s): This was invented by Herman Hollerith to tabulate 1890 US census data. It was electrically powered and, used punched cards.

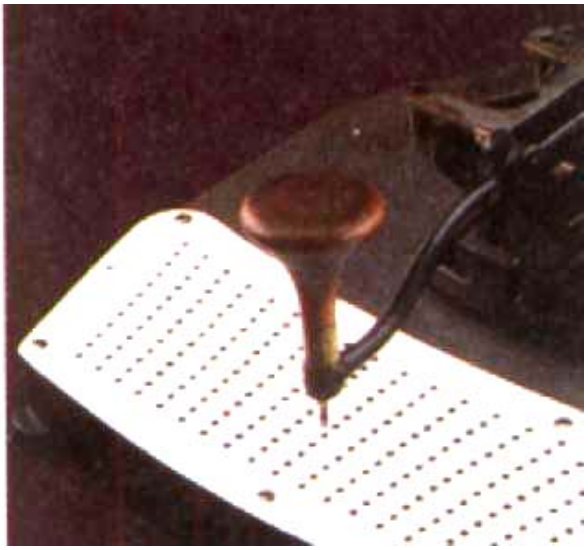
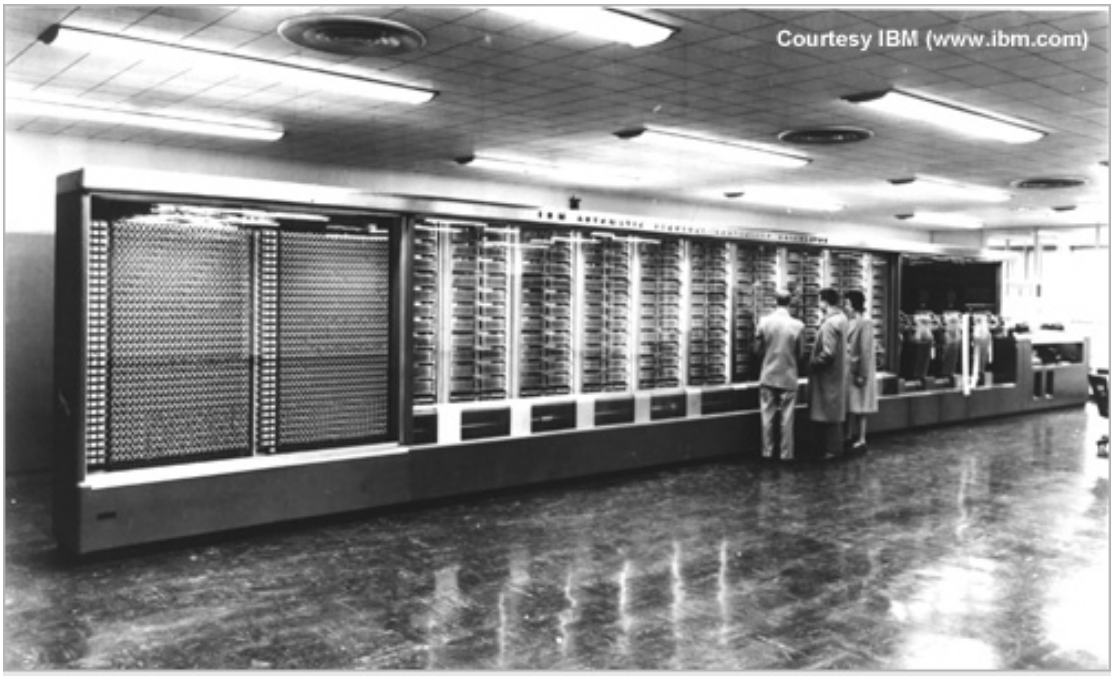


Figure 1.17: Punch card

Mark I (1944): This was invented in 1944 by Dr. Howard Aiken. The idea is based on programmable, general purpose computer (figures 2.5,2.6) .



The Harvard Mark I

Figure 1.18: MARK I

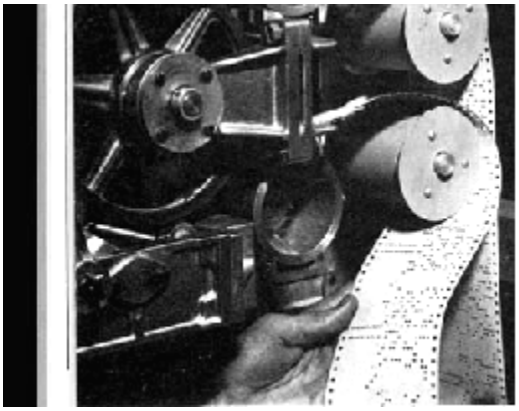


Figure 1.19: The punch card reader of MARK I

The following data with the years will give us a good understanding as how computers have evolved over the past.

- In 1642 Biaise Pascal introduced the Pascaline digital machine.
- In 1822 Charlet Babbage introduces the Difference Engine and later the Analytical Engine (as he called them), a general purpose computing machine.
- In 1937 John V. Atanasoff created the Atanasoff-Berry Computer (ABC). This is considered as the first electronic computer.
- In 1945 John von Neuman specified the architecture of the EDVAC, which introduced the stored-program computer concept.
- In 1946 John Mauchly and J. Presper Eckert introduced the ENIAC, an electronic computing machine.
- In 1947 William Shockley, Walter Brattain and John Bardeen was successful in testing the point-contact transistor. This made the semiconductor revolution which helped to reduce the size of computers.
- In 1949 Maurice Wilkes at Cambridge University released the EDSAC, the first real stored-program computer.
- In 1952 UNIVAC I was developed and this is the first commercial computer which got a large amount of public attention.
- In 1953 IBM releases the IBM 701. This is IBMs first electronic computer.
- In 1955 Bell laboratories introduced the TRADIC, the first fully transistorized computer.
- In 1958 Jack Kilby at Texas Instruments created the first integrated circuit (IC).
- In 1969 the ARPAnet was developed. (This became the base for Internet later.)
- In 1971 IBM invented the 8” floppy disk.
- In 1972 Intel introduced the Intel 8008 microprocessor.
- In 1973 Robert Metcalfe introduced the Ethernet method for network connections.
- In 1974 Xerox Palo Alto Research Centre designed the first workstation with mouse input available.
- In 1977 Apple Computers introduced Apple II.
- In 1979 Motorola introduced the 68000 microprocessor.

- In 1980 Segate Technology created the first hard disk drive for microcomputers.
- In 1981 Xerox introduced the Star, the first personal computer with a graphical user interface (GUI).
- In 1981 Sony introduced the 3 " floppy drives.
- In 1982 Sony introduced the first CD player.
- In 1984 Apple Computer introduced the Macintosh, the first successful mouse driven, GUI based computer.
- In 1984 IBM released the personal computer PC-AT. This introduced the 16-bit ISA bus and is the computer which all modern personal computers are based.
- In 1985 Philips introduced the first CD-ROM drive.
- In 1987 IBM introduced its PS/2 machines. This machine made the 3 " floppy disk drives and VGA video standards for personal computers.
- In 1988 EISA architecture was developed.
- In 1990 the World Wide Web (WWW) was introduced. Hyper Text Markup Language (HTML) also was introduced.
- In 1995 Microsoft introduced the Windows 95 operating system. This is the first main 32-bit operating system.
- In 1997 Intel released the Pentium II microprocessor.
- In 1997 AMD released the K6 microprocessor.
- In 1998 Microsoft released Windows 98.
- In 1999 Intel released the Pentium III, with SSE (Streaming SIMD Extensions) added.
- In 1999 AMD released Athlon.
- In 2000 Microsoft released Windows Me and Windows 2000.
- In 2000 both Intel and AMD released processor at 1 GHz.
- In 2000 Intel released Pentium 4. It belongs to Intel Architecture 32-bit (IA-32) family.
- In 2001 Intel released the Itanium processor. This is Intel’s 64-bit processor for personal computers.
- In 2001 Microsoft released Windows XP.
- In 2002 Intel released the Pentium 4 with 3GHz speed. This processor also included the Hyper-Threading (HT) technology.
- In 2003 Intel released the Pentium M, a processor designed for mobile computer systems.
- In 2005 Intel released the dual core processor named Core Duo

1.2.2 The mechanical computer

Charles Babbage a Mathematics professor is considered as the father of computers. In 1822 Charles Babbage invented the Difference Engine (figure 2.7) and later the

Analytical Engine, which was general-purpose computing machine. The Analytical Engine was designed to store one thousand 50 digit numbers (words) for calculations and decisions. It had a storage capacity (memory) of 1000 such numbers. It included built-in functions that a general purpose computer would need. It also included conditional functions to change the order of instructions execution (otherwise instructions would be executed in numerical sequence). The Analytical Engine also used punch cards to program the machine. It operated using steam power.

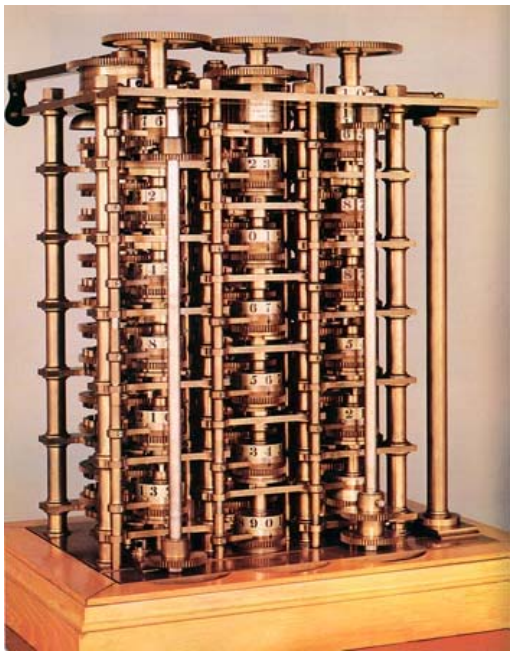


Figure 1.20: Difference Engine

The Analytical Engine included the units which a general purpose computer has today. Therefore it is considered the real predecessor for general purpose computers used today. The units included were:

- An input device: Punched cards provided the input.
- A control unit: A unit used to control or program the processor.
- A processor (or calculator) : A unit which consisted mechanical parts to process data.
- Storage: A unit which could hold 1000 50-digit numbers.
- An output device: Used to print the final results.

Any how this computer was not completed, due to the problems of the technology availability at this period.